THE ROAD NETWORK IS THE BICYCLE NETWORK:
BICYCLE SUITABILITY MEASURES FOR ROADWAYS AND SIDEPATHS

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Introduction

Bicycle planning has been a rapidly growing field over the past decade. Local, regional, state and federal units of government are recognizing that bicycling is an efficient, healthy, inexpensive and viable form of transportation that can help ease traffic congestion and air quality problems while providing access to destinations for people who cannot or choose not to drive. The federal transportation bills of 1991 ("ISTEA") and 1998 ("TEA-21") have been an important impetus, providing dedicated funding for bicycle facilities and requiring consideration of bicycling in metropolitan planning organization (MPO) transportation plans. This has helped spur the development of bicycle plans, policies, and facility design guidance.

Although cycling is a popular recreational activity, it is underutilized as a form of transportation, in part due to a lack of comfortable, safe and direct biking facilities. Transportation plans and policies from the national to local level now call for bicycle-friendly roads to more safely accommodate those who bike by choice or necessity. *Destination 2020*, the regional transportation plan for northeastern Illinois, includes the following policy: "Consider the specific access needs of bicyclists and pedestrians in arterial and collector project planning, especially on those routes that provide unique access to destinations or across barriers."[1]

To improve the cycling environment, many communities are developing bikeway networks, a combination of on and off road routes that are specifically designated for bicycle travel. Designation as a bikeway implies a road or path has bicycle "friendly" features, such as comfortable traffic volumes and speed, enough room for different road or path users traveling at different speeds, easy to navigate intersections and directness. For example, the 2000 edition of the city of Chicago's bikeway map features a 300-mile network of streets with existing and planned bicycle lanes, recommended routes, and shared-use paths. Cyclists can use it to find streets that are more hospitable to cyclists than others, particularly for longer trips, and planners can use it to coordinate bicycle accommodations with other road projects. For example, 13 miles of bike lanes are scheduled to be implemented in Chicago in 2001 as part of various IDOT and CDOT reconstruction and resurfacing projects.

Chicago's bikeway map also features another important network of bicycle facilities—the entire system of roads in the city. Most bicycle trips involve travel along streets that are not specifically designed or designated for cyclists. Low traffic volume and speed residential streets are often already quite suitable for cycling, particularly for short, local trips. These can be considered feeders into the bikeway network. Arterial and collector streets, with higher traffic volume and speeds, can be more intimidating when there is not enough room for motorists and cyclists to pass one another without having to change lane position. Restriping streets to provide a bicycle lane or wide outside curb lane can increase the road's suitability for cycling. However, many destinations are served by roads that are not accommodating for bicycle travel. Because cyclists tend to seek direct routes, and not all cyclists have or use a bikeway map to identify preferred routes, it is important to strive to make all transportation corridors suitable for cycling.

Technical resources are available to assist in the development of bicycle friendly facilities. In 1999, the American Association of State and Highway Transportation Officials (AASHTO) released the *Guide for the Development of Bicycle Facilities*.[2] It includes design guidance for bike lanes, paved shoulders, wide outside curb lanes, marked routes and shared used paths. For example, it suggests that bicycle lanes have a minimum width of five feet when placed next to a parking lane to provide enough room for cyclists to avoid opening car doors. It also outlines operational concerns associated with sidepaths (shared-use paths that are located immediately adjacent to a roadway), such as intersection conflicts and cycling against the flow of motorized traffic. Many states (including Illinois) and communities use AASHTO's guidelines as standards.

Including bicycle facilities that are designed to meet AASHTO standards can improve a transportation corridor's suitability for cyclists. However, the type of facility chosen and the character of the traffic mix and adjacent land-use will influence the level of suitability. Cycling in a wide outside curb lane on a road with heavy truck traffic and many driveways feels different than cycling on one without. Other factors that influence a cyclist's comfort and perception of safety include pavement conditions, parking turnover rate and motorized traffic speed and volume (or, in the case of shared use paths, non-motorized traffic speed and volume). Objective performance measures, analogous to those used for motorized travel, are useful for helping planners, engineers and decision makers evaluate existing road and path facilities, identify appropriate improvements and prioritize projects. This paper compares four existing measures of roadway suitability for cycling and introduces a measure for sidepath suitability.

Suitability Measures for Bicycles as Planning Tools

Most bicycle suitability measures quantify a cyclist's *perceived* safety on a particular roadway, as a function of factors including traffic volume, traffic speed, pavement condition, and lane width. This perception of a safe bicycling environment is a major determinant in an individual's mode choice of bicycling. Suitability scores are translated into a "Level of Service" (LOS) from A to F, consistent with the terminology of other transportation performance measures. Other travel modes use measures based on vehicular flow and capacity, but their LOS gradations are also ultimately based on human perception – for example, motorist tolerance of traffic delays and conditions[3].

A quantified measure of roadway suitability for bicycle travel could be used for:

- Identification of needs and missing links
- Comparison of various design options
- Prioritization of bicycle facility projects
- Development of bicycle suitability maps
- A term in project evaluation formulas, to provide "credit" for making roads bike-friendly
- The "travel impedance" in both the trip distribution and assignment steps of travel forecasting models for urban utilitarian bicycling – a field still under development[3].

Comparison of Roadway Suitability Measures

The League of Illinois Bicyclists and the Data Standards Working Group of CATS' Bicycle and Pedestrian Task Force compared four roadway suitability formulas for purposes of recommending one of them. The study included two leading national measures: the Bicycle Compatibility Index (BCI)[4,5] and the Bicycle Level of Service (BLOS)[3]. Both the BCI and BLOS can be calculated using an on-line web form at www.bikelib.org/roads/blos/intro.html. Also examined were the bicycle suitability map criteria of both the Illinois Department of Transportation (IDOT)[6] and the Chicagoland Bicycle Federation (CBF)[7]. Summaries of each are provided below.

Bicycle Compatibility Index (BCI)[4,5]

The Federal Highway Administration developed the Bicycle Compatibility Index (1998), based on the research of the University of North Carolina Highway Safety Research Center, Sorton and Walsh[8], and others. Like the other three measures surveyed here, BCI evaluates mid-block road segments but not intersections. Bicyclists in the study were shown videotapes of selected road segments. Eight independent variables related to their perceived safety were selected along with three adjustment factors. BCI stresses the importance of bike lanes and paved shoulders over 3' wide. It has a linear dependence on traffic volume, resulting in a very small effect until traffic volumes are quite high. Included are terms for parking occupancy and turnover, heavy vehicle volume, and smaller terms for adjacent development type and right-turning traffic. The basic model, excluding adjustment factors, has a very high correlation coefficient of $R^2 = 0.89$.

$$BCI = 3.67 - 0.966BL - 0.410BLW - 0.498CLW + 0.002CLV + 0.0004OLV + 0.022SPD + 0.506PKG - 0.264AREA + AF$$

where:

BL = presence of bike lane or paved shoulder > 0.9m: no 0, yes 1
BLW = bike lane (or paved shoulder) width in meters (to the nearest tenth)
CLW = curb lane width in meters (to the nearest tenth)
CLV = curb lane volume in vehicles per hour in one direction
OLV = other lane(s) volume, same direction, in vehicles per hour
SPD = 85th percentile speed of traffic in km/hr
PKG = presence of parking lane with more than 30% occupancy: no 0, yes 1
AREA = type of roadside development: Residential 1, other type 0
AF = ft + fp + frt
    ft = adjustment factor for truck volumes (see below)
    fp = adjustment factor for parking turnover (see below)
    frt = adjustment factor for right-turn volumes (see below)

Hourly Curb Lane Large Truck Volume[1]	
≥ 120	ft=0.5
60-119	0.4
30-59	0.3
20-29	0.2
10-19	0.1
< 10	0

Parking Time Limit (min)	
< 15	fp=0.6
16-30	0.5
31-60	0.4
61-120	0.3
121-240	0.2
241-480	0.1
> 480	0

Hourly Right-Turn Volume[2]	
≥ 270	frt=0.1
< 270	0

[1] Large trucks are defined as all vehicles with six or more tires.
[2] Includes total number of right turns into driveways or minor intersections along the road.

Bicycle Compatibility Index ranges associated with level of service (LOS) designations:

BCI Range	≤ 1.50	1.51-2.30	2.31-3.40	3.41-4.40	4.41-5.30	> 5.30
LOS Level	A	B	C	D	E	F
Compatibility Level	Extremely High	Very High	Moderately High	Moderately Low	Very Low	Extremely Low

Bicycle Level Of Service (BLOS)[3]

Landis et al. developed the Bicycle Level of Service (1997) using a different technique. The research involved riders on actual field courses, instead of cyclist reaction to filmed conditions. BLOS is similar to BCI in its sensitivity to curb lane width. Its traffic volume dependence is logarithmic, increasing the impact of changes at low and medium traffic levels. Additional paved shoulder or bike lane width affect the BLOS score somewhat more than the BCI. Ignored are development type, parking, and right-turning traffic, but bad pavement surfaces and higher heavy vehicular traffic have a major impact. Further work is planned for rural highways and for central business district roads with high parking turnover. The model has a high correlation coefficient ($R^2 = 0.73$) and can be used in metropolitan areas throughout the United States.

$$\mathrm{BLOS} = 0.507 \ln(\mathrm{Vol}_{15}/L_n) + 0.199\, \mathrm{SP}_t(1+10.38\mathrm{HV})^2 + 7.066(1/\mathrm{PR}_5)^2 - 0.005\, W_e^2 + 0.760$$

where:

Vol_{15} = volume of directional traffic in 15 minutes = $(\mathrm{ADT} * D * K_d) / (4 * \mathrm{PHF})$
    ADT = Average Daily Traffic on the segment
    D = Directional Factor
    K_d = Peak to Daily Factor
    PHF = Peak Hour Factor
L_n = number of directional through lanes
SP_t = effective speed limit = $1.1199 \ln(\mathrm{SP}_p - 20) + 0.8103$, where SP_p is the posted speed limit
HV = percentage of heavy vehicles (as defined in the 1994 Highway Capacity Manual)
PR_5 = FHWA’s 5-point pavement surface condition rating (5=best)
W_e = average effective width of outside through lane:
    $W_e = W_v - (10' * \mathrm{OSPA})$ where $W_l = 0$

$W_e = W_v + W_l\,(1 - 2 * OSPA)$ where $W_l > 0$ & $W_{ps} = 0$
$W_e = W_v + W_l - 2\,(10' * OSPA)$ where $W_l > 0$, $W_{ps} > 0$, and a bike lane exists.
W_t = total width of outside lane (and shoulder) pavement
OSPA = fraction of segment with occupied on-street parking
W_l = width of paving between outside lane stripe and edge of pavement
W_{ps} = width of pavement striped for on-street parking
W_v = effective width as a function of traffic volume
$W_v = W_t$ if ADT>4000 veh/day
$W_v = W_t\,(2 - (ADT/4000))$ if ADT<4000 and road is undivided and unstriped.

Bicycle Level of Service ranges associated with level of service (LOS) designations:

BLOS Range	≤ 1.50	1.51-2.50	2.51-3.50	3.51-4.50	4.51-5.50	> 5.50
LOS Level	A	B	C	D	E	F

IDOT (Illinois Department of Transportation) Bicycle Map Criteria[6]

This formula was created by IDOT before other algorithms were available. It has been used since 1994 to automatically generate IDOT's district bike suitability maps from its database of state, county, and township roads. The ratings were derived from a consensus of a panel of bicyclists. Each of four terms – type of pavement, lane width, paved shoulder width, and average daily traffic – is discretized into three ranges. It is primarily intended to rate rural roads – no speed limit term exists and typical rural speeds are assumed. Almost all urban roads, particularly in the Chicago area, appear as red (poor). The upper range for Average Daily Traffic volume per lane covers a wide range, starting at 2000 vehicles/day. Very low ADT/lane (<750) rural roads have a higher suitability score than those of other measures. Significant credit is given for a 12' (or more) curb lane and for a 4' (or more) paved shoulder/bike lane.

Add these four terms for a maximum of 1.000:

Roadway Surface:	High = 0.054	Low = 0.019	Oil/chip = 0.006
Lane Width:	≥ 12' = 0.189	10' - 11.9' = 0.052	< 10' = 0.019
Shoulder Width (paved):	≥ 4 = 0.132	1' - 3' = 0.033	None = 0.012
ADT/Lane:	< 750 = 0.374	750-2000 = 0.082	> 2000 = 0.028

For ADT/Lane < 2000 (or 200 trucks):

IDOT Score	≤ 0.150	0.150 - 0.420	> 0.420
Rating	Poor/Red	Fair/Yellow	Good/Green

For ADT/Lane > 2000 (or 200 trucks):

IDOT Score	≤ 0.300	> 0.300
Rating	Poor/Red	Fair/Yellow

No road segment with a CRS (surface condition rating) of less than 4.5 (new pavement = 9.0) can be rated GREEN, regardless of ADT. The ratings are interpreted as follows:

- Good/Green roads are "most suitable for the average or experienced cyclist."
- Fair/Yellow roads are "cautionary for cycling, but may be suitable for more experienced cyclists who are comfortable with riding in traffic conditions."
- Poor/red roads "should be avoided by cyclists."

CBF Bicycle Map Criteria[7]

This chart was developed in 2000 for the upcoming Chicagoland Bicycle Federation's 4th edition bike map of the Chicago metropolitan area. Map volunteers used the chart to rate roads based on available data and/or direct observation. The only factors considered were traffic volume, traffic speed, and curb lane width (plus paved shoulder/bike lane width). Unlike the other measures, the resulting score is discretized into four levels. The differences in the area's road conditions were somewhat amplified to ensure a good distribution into the three ranges of relative recommendation. The measure is very dependent on traffic speed and width of paved shoulders/bike lanes. It also has the strongest dependence on curb lane width.

Green roads are highly recommended, Yellow roads have a medium recommendation, and Red roads have a cautionary recommendation.

	Very Low ADT/lane (Under 500)	**Low ADT/lane** (500-1250)	**Medium ADT/lane** (1250-5000)	**High ADT/lane** (Above 5000)
Low Speed (Under 35 mph)	All widths Green	All widths Green	12' or more = Green <12' = Yellow	12' or more = Yellow <12' = Red
Medium Speed (35-40 mph)	All widths Green	12' or more = Green <12' = Yellow	12' or more = Yellow <12' = Red	12' or more = Red <12' = Not Recomm.
High Speed (45-50 mph)	12' or more = Green <12' = Yellow	14' or more = Green 12-13' = Yellow <12' = Red	14' or more = Yellow 13' = Red <13' = Not Recomm.	14' or more = Red <14' = Not Recomm.
Very High Speed (Above 50 mph)	12' or more = Green <12' = Yellow	14' or more = Green 12-13' = Yellow <12' = Red	14' or more = Red <14' = Not Recomm.	Not recommended, without paved shoulders

Notes: Paved shoulders or bike lanes less than 4' are simply added to curb lane width. Paved shoulders or bike lanes 4'-7' upgrade ratings by two levels (Not Recommended to Yellow, Red to Green). Paved shoulders or bike lanes 8' or more upgrade all ratings to Green.

Sensitivity Analysis and Discussion

The table in Appendix A compares the sensitivities of the four suitability measures to changes in key roadway factors. For example, the effects of lane width and paved shoulders/bike lanes are considered for typical rural, residential, urban collector, and urban arterial roads. For each road type and each measure, extra lane width improves suitability. Paved shoulders or bike lanes have an even more dramatic impact, especially for BLOS and CBF.

- Effect of increasing traffic volume: BLOS, with a logarithmic term, worsens steadily from very low to very high traffic. CBF and especially BCI show relatively little change until higher traffic levels. IDOT's emphasis on rural roads is evident by a very wide range at the higher volume end.
- Effect of pavement condition: Only BLOS and, to a lesser extent, IDOT, are affected.

- Effect of increasing speed limit: Both BCI and BLOS change by one level over the range. CBF is more sensitive to traffic speed. IDOT does not have a speed term.
- Effect of heavy vehicle traffic: BLOS has a significant effect. BCI is the only other measure even slightly affected.
- Residential roads: Even without extra width, these are very good places to ride, according to CBF and IDOT. Paved shoulders or bike lanes improve the BLOS and BCI level from LOS C to LOS B or A.
- Rural roads: CBF is the most sensitive to extra lane width. The higher speed worsens BCI and BLOS by roughly one level, but it doesn't affect IDOT's score.
- Urban collectors: Compared to residential roads, the higher traffic worsens BCI by half a level, BLOS and CBF by a full level, and drops IDOT to its worst category.
- Urban arterials: While extra lane width helps somewhat, only paved shoulders or bike lanes can bring these roads into acceptable ranges.

From this analysis, the Data Standards Working Group recommended the Bicycle Level of Service to the CATS Bicycle and Pedestrian Task Force. The preference for a numerical measure with a speed limit term ruled out CBF and IDOT. The group felt that the logarithmic traffic volume dependence of BLOS made it a better choice than BCI to rate the wide range of roads in the area. BLOS will first be used as part of a pilot program in Kane County's bicycle planning effort, currently underway. Based on the quantified bicycle suitabilities of roads in the county, needs and gaps will be identified and prioritized. Evaluation will follow before a full recommendation will be made to regional agencies.

Agencies in other states are already using BLOS in planning efforts. The Delaware Valley Regional Planning Commission has used it to identify "high-priority independent retrofit projects designed to improve the level of service for bicycling" in Montgomery County.[10] 28 miles of roads were selected for study representing the highest priority for implementation (as determined by county planning staff, the bicycling community and the general public). The study identified specific problem areas and made detailed recommendations for how to bring all segments of the roadways up to a BLOS of "C" or better, or to a cross section recommended by the FHWA for experienced cyclists.

A New Sidepath Suitability Measure

Sidepaths are shared use trails parallel to a roadway, in the space usually occupied by sidewalks. These bicycle facilities are becoming increasingly more common. This is especially true in the suburbs, where development patterns often leave a higher speed arterial as the only option for connectivity. The bicycle-car accident rate is substantially higher for sidepaths than for on-street bike improvements such as bike lanes and wide curb lanes[9]. The AASHTO *Guide for the Development of Bicycle Facilities* details reasons for these intersection safety problems, many stemming from a lack of visibility caused by sidepath separation from the road intersection. For most cases, AASHTO recommends on-street bike facilities over sidepaths. However, large numbers of inexperienced bicyclists and public agencies prefer sidepaths in almost every case, because of a belief of higher safety.

In the absence of any known nationally-accepted measures, the risk factors described by AASHTO have been quantified in the North Aurora (Illinois) Non-Motorized Transportation

Plan[11]. The following algorithm, rating the suitability of a sidewalk or sidepath as a bicycle facility, can be used to:

- Rate existing sidepaths
- Determine whether a new sidepath would be an appropriate option
- Suggest safety improvements for existing or planned sidepaths

The model has not been calibrated – it is simply an estimate of the relative importance of key terms, checked by observation during the North Aurora plan development. Six factors are considered below. Assumed is that bicyclists will travel in both directions on the sidepaths, even though those riding against the flow of parallel traffic are at higher risk.

1) Intersection Traffic Score. The volume and speed of traffic significantly affect the risk of collision with turning vehicles. Determine the Intersection Traffic Score (ITS) from the following:

$$ITS = Spd * Vol *[R+(2A)+(4B)] / M;$$

Where:
R = Number of residential intersections (driveways) on the sidepath segment,
A = Number of minor commercial intersections and streets (<1000 ADT),
B = Number of major commercial intersections and streets (≥1000 ADT),
M = Length of segment in miles
Spd = Speed limit factor, for the parallel street: ≤ 30 mph = 1, 35-40 = 2, ≥ 45 = 3.
Vol = Traffic ADT factor, parallel street: ≤2,000 = 1; 2,000-10,000 = 2; ≥10,000 = 3.

Add the appropriate number of suitability points for the ITS.

Intersection Traffic Score ITS	0	1-40	41-80	81-120	121-160	161-200	201-240	> 240
Points	0	1	2	3	4	5	6	7

2) Continuity. Discontinuities (major gaps, or sidepath ends) may force cyclists to ride through grass, etc., and enter the roadway awkwardly. Often cyclists will avoid sidepaths with these gaps. Add **4 points** if major discontinuities exist.

3) Curb cuts. Uncut curbs compromise cyclist movement and attention at intersections. Add **3 points** if any intersections are lacking curb cuts.

4) Pedestrian use. Sidewalks and sidepaths are used by both bicyclists and pedestrians. Insufficient width increases user conflict. (However, extra width encourages higher cyclist speeds – which is a problem at incorrectly-designed intersections.) Add points according to the following pedestrian use chart:

Low (rare)	Medium (sometimes)	High (often)
0-5' = **1 point**	0-5' = **2 points**	0-5' = **4 points**
>5' = **0 points**	6-7' = **1 point**	6-7' = **2 points**
	>7' = **0 points**	>7' = **1 point**

5) Crosswalks. Visible crosswalks can help make motorists more aware of non-motorized traffic. Sometimes 2 parallel painted stripes are sufficient. At busier intersections, ladder-style crosswalks and other techniques enhance visibility. Add **2 points** if crosswalks are necessary but absent. Add **1 point** if there are some crosswalk markings, but more visibility is warranted for that intersection type. Add **0 points** for appropriately marked crossings. Take the average crossing for the segment.

6) Intersection sidepath/road separation. AASHTO recommends that sidepaths be brought close to the parallel road at intersections, so motorists more easily see and consider bicyclists during their approaches. The intersecting road's vehicular stop line should be in back of the sidepath crossing – cyclists must not weave through stopped traffic when crossing. Add **5 points** if the crossing goes through stopped traffic. Add **3 points** if the crossing is not brought "close enough" to the parallel road. Add **1 point** when the crossing is brought close to the road. (Paved shoulders and bike lane crossings would add 0 points.) Again, take the average crossing for the segment.

Add together all the points for the sidepath suitability score. Ranges of suitability are:

Points	0-7	8-9	10-11	12 or more
Sidepath Suitability	Most suitable	Somewhat suitable	Least suitable	Not suitable

The algorithm is available as an on-line web form[10] at www.bikelib.org/roads/blos/intro.html.

Consider three sidepath examples. The first is along a high-speed (50 mph), high-volume (20,000 ADT) outer suburban arterial with only four major retail intersections over 1 mile. Some pedestrians use the 8' sidepath, which has some subtle crosswalk markings. The intersections are safely in front of the stoplines, but not particularly close to the parallel road. Its suitability score is 8 – somewhat suitable. An improvement to "most suitable" (5) can be easily made by including high-visibility crosswalks at intersections closer to the road.

The second example is a 6' wide sidewalk/sidepath along a significant residential road (2500 ADT, 30 mph) with 20 driveways and 4 minor side streets in a half-mile. Some curb cuts are missing. Pedestrians are often present. There are no crosswalks at the relatively quiet intersections, which are not close to the parallel road. The score of 12 (not suitable) could be improved to an 8 (somewhat suitable) by adding the curb cuts and parallel stripes at the side street crossings. An on-road facility might be a better option, however.

Another sidepath is being considered along a 35 mph, 15,000 ADT arterial in a business district with 10 minor and 5 major commercial entrances or side streets in a half-mile. The 8' trail with high pedestrian use will have gaps at vacant lots, obliging future developers for the construction. There are no plans for crosswalk markings at the commercial entrances, and the intersections are set back from the road. With a score of 17, clearly this would be an unsuitable sidepath. Design improvements could be made: ladder-style crosswalks at major entrances and streets, simple crosswalks at minor intersections, intersections closer to the street, and building the entire sidepath at one time. Even with these, the best score possible in this situation is 9 – somewhat suitable. A bike lane would be a better choice.

Conclusion

Bicycle suitability measures for roadways and sidepaths can be used as analytical tools for planning, prioritization, and design. Four roadway measures have been studied and compared. A sidepath measure has been informally developed – further research is needed. These and other tools are necessary to mainstream and bring objectivity to bicycle planning.

References

[1] Chicago Area Transportation Study, Destination 2020 (Chicago, IL 1997)

[2] American Association of State Highway and Transportation Officials, Guide for the Development of Bicycle Facilities (Washington DC, AASHTO, 1999).

[3] Landis, Bruce, "Real-Time Human Perceptions: Toward a Bicycle Level of Service," Transportation Research Record 1578 (Washington DC, Transportation Research Board, 1997).

[4] "Development of the Bicycle Compatibility Index: A Level of Service Concept, Final Report," FHWA-RD-98-072 (1998).

[5] "Development of the Bicycle Compatibility Index: A Level of Service Concept, Implementation Manual," FHWA-RD-98-095 (1998).

[6] Illinois Department of Transportation memo by Craig Williams, September 5, 1994.

[7] Chicagoland Bicycle Federation memo by Randy Neufeld and Ed Barsotti, August 2000.

[8] Sorton, Alex and Thomas Walsh, "Bicycle Stress Level as a Tool To Evaluate Urban and Suburban Bicycle Compatibility," Transportation Research Record 1438 (Washington DC, Transportation Research Board, 1994).

[9] Watchel, Alan and Diana Lewiston, "Risk Factors for Bicycle-Motor Vehicle Collisions at Intersections," ITE Journal (Washington DC, Institute of Transportation Engineers, Sept. 1994)

[10] Delaware Valley Regional Planning Commision, Opportunities for On-Road Bicycle Facilities in Montgomery County (Philadelphia, PA, 2000)

[11] League of Illinois Bicyclists, North Aurora (Illinois) Non-Motorized Transportation Plan, to be published, 2001.

Appendix A-- **Sensitivities of Four Bicycle Suitability Measures to Changes in Key Roadway Factors**

Curb Lane Width [ft]	Paved shldr/ bike lane [ft]	Daily traffic volume [ADT]	Speed Limit [mph]	Heavy Veh [%]	Surf. Cond. [1-5, 5 best]	Bicycle Compat. Index [BCI]	BCI grade	Bicycle Level of Service [BLOS]	BLOS grade	IDOT bike maps [IDOT]	IDOT rating color	CBF new bike map [CBF]
Low Traffic, Low Speed, Residential Rd—effects of widths & paved shoulders/bike lanes												
10	0	1200	30	5	4	3.20	C	3.39	C	0.492	Green	Green
12	0	1200	30	5	4	2.90	C	3.17	C	0.629	Green	Green
14	0	1200	30	5	4	2.60	C	2.91	C	0.629	Green	Green
10	***4***	1200	30	5	4	1.74	B	2.27	B	0.612	Green	Green
12	***4***	1200	30	5	4	1.43	A	1.89	B	0.749	Green	Green
Low Traffic, High Speed, Rural Rd—effects of widths & paved shoulders/bike lanes												
10	0	1200	55	5	4	4.35	D	4.04	D	0.492	Green	Red
12	0	1200	55	5	4	4.05	D	3.82	D	0.629	Green	Yellow
14	0	1200	55	5	4	3.75	D	3.56	D	0.629	Green	Green
10	***4***	1200	55	5	4	2.89	C	2.92	C	0.612	Green	Green
12	***4***	1200	55	5	4	2.58	C	2.54	C	0.749	Green	Green
12	***8***	1200	55	5	4	2.08	B	0.62	A	0.749	Green	Green
Medium Traffic, Urban Collector Road—effects of widths & paved shoulders/bike lanes												
10	0	5000	35	5	4	3.88	D	4.32	D	0.146	Red	Red
12	0	5000	35	5	4	3.58	D	4.10	D	0.283	Red	Yellow
14	0	5000	35	5	4	3.27	C	3.84	D	0.283	Red	Yellow
10	***4***	5000	35	5	4	2.42	C	3.20	C	0.266	Red	Green
12	***4***	5000	35	5	4	2.11	B	2.82	C	0.403	Yellow	Green
12	***8***	5000	35	5	4	1.61	B	0.90	A	0.403	Yellow	Green
High Traffic, Urban Arterial Rd—effects of widths & paved shoulders/bike lanes												
10	0	15000	45	5	4	5.06	E	5.14	E	0.146	Red	Not Rec.
12	0	15000	45	5	4	4.76	E	4.92	E	0.283	Red	Not Rec.
14	0	15000	45	5	4	4.45	E	4.66	E	0.283	Red	Red
10	***4***	15000	45	5	4	3.59	D	4.02	D	0.266	Red	Yellow
12	***4***	15000	45	5	4	3.29	C	3.64	D	0.403	Yellow	Yellow
12	***8***	15000	45	5	4	2.79	C	1.72	B	0.403	Yellow	Green
Effect of Increasing Traffic Volume												
12	0	***100***	35	5	4	3.27	C	2.12	B	0.629	Green	Green
12	0	***400***	35	5	4	3.29	C	2.82	C	0.629	Green	Green
12	0	***1200***	35	5	4	3.34	C	3.38	C	0.629	Green	Green
12	0	***5000***	35	5	4	3.58	D	4.10	D	0.283	Red	Yellow
12	0	***15000***	35	5	4	4.40	D	4.66	E	0.283	Red	Red
Effect of Pavement Condition												
12	0	5000	35	5	***5***	3.58	D	3.95	D	0.283	Red	Yellow
12	0	5000	35	5	***2***	3.58	D	5.43	E	0.248	Red	Yellow
Effect of Increasing Speed Limit												
12	0	15000	***25***	5	4	4.05	D	4.10	D	0.283	Red	Yellow
12	0	15000	***35***	5	4	4.40	D	4.66	E	0.283	Red	Red
12	0	15000	***45***	5	4	4.76	E	4.92	E	0.283	Red	Not Rec.
12	0	15000	***55***	5	4	5.11	E	5.10	E	0.283	Red	Not Rec.
12	4	15000	***25***	5	4	2.58	C	2.82	C	0.403	Yellow	Green
12	4	15000	***35***	5	4	2.94	C	3.38	C	0.403	Yellow	Green
12	4	15000	***45***	5	4	3.29	C	3.64	D	0.403	Yellow	Yellow
12	4	15000	***55***	5	4	3.65	D	3.82	D	0.403	Yellow	Yellow
Effect of Heavy Vehicle Traffic												
12	0	5000	35	***0***	4	3.58	D	3.10	C	0.283	Red	Yellow
12	0	5000	35	***5***	4	3.58	D	4.10	D	0.283	Red	Yellow
12	0	5000	35	***10***	4	3.68	D	5.52	F	0.283	Red	Yellow